High-Altitude Pseudo-Satellite

SKYDWELLER
Perpetual Flight™

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Background Research

Solar Impulse 2 [1]

Credit: Skydweller [1]

- 5 continuous days over ocean with pilot
- 2,300 kg and wingspan of 72 m
- Missions include:
  - Solar flight around the world
  - "Natural resource monitoring, data collection, weather forecasting, and emergency operations surveillance, and Internet and 5G for remote areas." [2]

Credit: Airbus [4]

Zephyr [3]

- Record 64 continuous days in flight
- 75 kg and wingspan of 25 m
- Missions include:
  - Direct-to-Device mobile connectivity
  - 3+ optical devices

Objectives

Primary Objectives

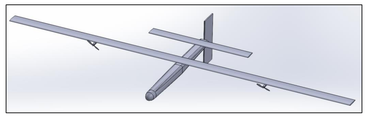
- Payload: 50 kg with a 750-Watt power requirement
- Dimensions of payload bay: W x H x L = 0.45 m x 0.45 m x 1.0 m
- Design capable of preforming the following mission:
  - Takeoff
  - Climb to 16 km altitude
  - Loiter for 90 days in a 5 km radius
  - Final decent and land

Secondary Objectives

- Energy consumed over a 24-hour period is less than energy available from solar irradiance
- Best value design
  - Acquisition and operational costs
- 10-year service life

Design Process

First Iteration



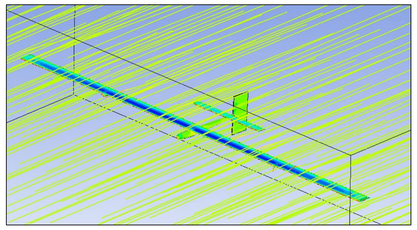
Statistics:

- Empirical Sizing Calculations
- Cruise Endurance is 5 hours
- Battery Specific Energy is 550 Wh/kg
  - Not considering power for system
  - Payload power is a separate battery
- Wing loading is 30 kg/m^2

MGTOW	612.8 kg
Wingspan	24.8 m
Wing Area	20.4 m^2
Cruise Velocity	25 m/s

Concerns to Address:

- Lower the wing loading
- Increase the endurance



Second Iteration

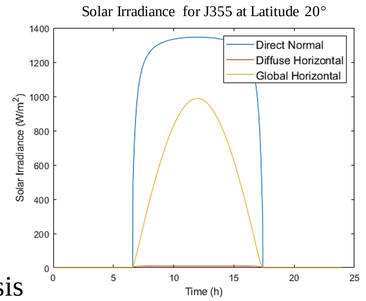
Statistics:

- Power to Weight reduced, Wing Loading is 10 kg/m^2
- Increased glide time
- Cruise Endurance is 8 hours
- Battery Specific Energy is 340 Wh/kg

MGTOW	610.7 kg
Wingspan	42 m
Wing Area	58.8 m^2
Cruise Velocity	10 m/s

Concerns to Address:

- Minimal solar model analysis
- Improve numerical accuracy



Third Iteration

Statistics:

- Implemented the following
  - Solar model (see chart)
  - Aircraft systems power
  - Tracking energy state over time
- Automated performance analysis
  - Allowed for batch testing

MGTOW	459.2 kg
Wingspan	42 m
Wing Area	58.8 m^2
Cruise Velocity	10 m/s

Concerns to Address:

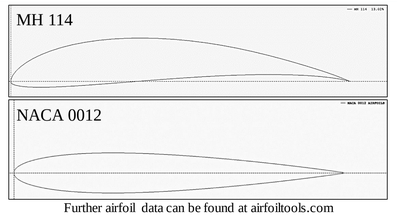
- More power for safe perpetual flight
- Calculation mistake discovered

References:

[1] "Around the World to Promote Clean Technologies." Solar Impulse, https://aroundtheworld.solarimpulse.com/.
[2] Lebleu, Tristan. "A Second Life for the Solar Impulse (si2) Airplane." Solar Impulse, Solar Impulse Foundation, 8 June 2022, https://solarimpulse.com/news/a-second-life-for-the-solar-impulse-si2-airplane#.
[3] "Aalto Haps." HAPS, https://www.aaltohaps.com/.
[4] Media Centre Airbus - Home, https://mediacentre.airbus.com/mediacentre/home.

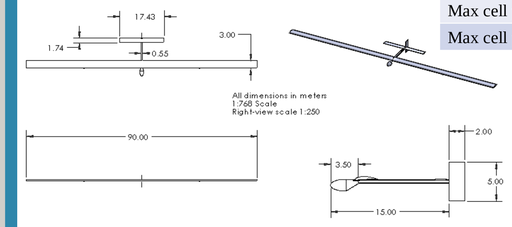
Final Design

- Wing Airfoil: MH 114
  - High lift / low speeds
- Tail Airfoil: NACA 0012
  - Symmetric to minimize airflow disturbances
- Wing area increased
- Wing loading comparable to current models
- Battery size increased
  - Primary cause to weight increase



Further airfoil data can be found at airfoiltools.com

Solar Cell and Power	
S_{wing}	270 m^2
S_{cell}	0.0153 m^2
Number of cells (90% of wing)	17,647 cells
$P_{required}$ (16 km)	4,823 W
$P_{required}$ (30 km)	12,076 W
Max cell power generated (16 km)	64,035 W
Max cell power generated (30 km)	66,225 W



MGTOW	595.3 kg
Wingspan	90 m
Wing Area	270 m^2
Cruise Velocity	14-43 m/s

Results

- Flight path
  - Circular spiral over 24 hours
  - Battery increases with altitude (see chart to the right)
- Costs of Aircraft (200 units)
  - Total: $75,942,824.65
  - Per Aircraft: $379,714.12
- Takeoff and Landing with bicycle landing gear